Acoustic Emission Analysis for Quantifying Internal Leak Flows in Industrial Valves

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Valves play a pivotal role in various industrial applications, facilitating the control of gas, liquid, or diphasic flows in critical sectors such as energy, oil and gas, water management, and chemistry. The occurrence of damage or maladjustment in valves can lead to detrimental consequences, including financial burdens, environmental concerns, and safety hazards. In this context, the detection of internal leak flows within valves becomes paramount, especially in sensitive environments like nuclear power plants. Acoustic emission measurement serves as a reliable technique for assessing these internal leak flows. To accurately quantify internal passing flows, meticulous control of the measurement chain is essential. This chain comprises a wide-band piezoelectric sensor operating within the frequency range of 150-950 kHz, a waveguide constructed from steel rod, a coupling medium (utilizing dough to eliminate air gaps between the sensor and waveguide), and the requisite electronic components for power supply and data processing. To achieve this, transfer functions of both the sensor and waveguide, accounting for coupling effects, were comprehensively characterized using white noise signals. The assessment of acoustic emissions resulting from leak flows hinges on the utilization of statistical parameters, notably the Average Signal Level (ASL). ASL is calculated from measurements obtained within a timeframe of approximately 0.13 seconds, covering the frequency bands of 150-300 kHz and 300-500 kHz. To acquire empirical data for analysis, we established a semi-industrial facility designed to simulate water and gas leak flows encountered in industrial settings. This facility encompasses a 500-liter tank, 10-inch pipes, and a test section equipped with nine calibrated orifices with diameters of 0.3, 0.5, and 0.8 mm, oriented in the direction of flow. Additionally, we investigated leak positions and bevel configurations with divergence angles of 10, 20, and 30 degrees. Leak flow simulations involved upstream pressures ranging from 2 to 50 bars, and concurrent measurements of fluid parameters, including pressures, temperatures, and flow rates. Through comprehensive analysis of our experimental acoustic emission data, we validated a model for quantifying leak flows, incorporating both fluid and valve parameters. This research contributes to the advancement of non-destructive testing techniques, particularly in ensuring the integrity and safety of industrial valve systems across various critical sectors.